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FINAL REPORT

IMPACT OF TILLAGE AND CROP ROTATION ON ASCOCHYTA BLIGHT OF LENTIL

19940010

Funded by
The Agriculture Development Fund

November 2000

Prepared by: AAFC

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102-00043/

Final Report, ADF Project 94000010

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Technical Summary

In the fall of 1994, a trial was initiated to assess the survival of *Ascochyta lentis* (cause of ascochyta blight) on naturally-infected lentil residue buried at 0, 5 and 10 cm depth in a clay-loam soil at Saskatoon. Samples were collected and assessed from 1995-1998. Inoculum levels in the spring of 1995 were almost an order of magnitude higher than the previous fall, indicating that the pathogen had spread in the infected residue and that a lentil crop planted on infected residue would be at high risk of a severe blight epidemic, irrespective of tillage management. Levels of the pathogen were highest in spring and low in fall. Inoculum potential declined slowly over the course of the trial, but the pathogen was still present (and infectious) in infected residue four years after the infected crop. Contrary to previously published reports, burial did not have a substantial impact on survival of *A. lentis*, but it substantially increased the rate of breakdown of lentil residue.

Field trials were conducted from 1995 to 1999 to examine: 1) the impact of crop rotation on survival (Saskatoon), and 2) the impact of tillage management on survival of the pathogen (Indian Head). Ascochyta blight was more severe in continuous lentil than in other crop rotations at both sites. There were no differences in blight severity in lentil when the intervening crop was canola, barley or pea. There was no difference in root rot severity between the continuous lentil treatment (5 of 5 years) and treatments with lentil in only 2 of 5 years. At Indian Head, severity was much higher under zero-tillage than under conventional tillage in the continuous lentil treatment, but only when conditions were conducive to blight development. Tillage did not affect disease severity when there was two intervening crops between successive lentil crops.

We conclude that that at least three crops between successive lentil crops are required to reduce levels of inoculum to acceptable levels. Tillage is unlikely to have an impact on blight severity, except in very short cropping rotations.

Technical report

Objectives:

1) To determine how long *Ascochyta lentis* survives in soil.
2) To examine the impact of crop rotation on survival of the pathogen.
3) To examine the impact of tillage management on survival of the pathogen.

Background

The economic returns of lentil production have been high relative to those for cereal crops in recent years. As a result, lentil acreage in western Canada has increased from a few hundred acres in the early 1970s to around a million acres per year in the 1990s. Zero-till management is being adopted by many growers in the dark-brown soil zone (where lentil is best adapted) to reduce wind and soil erosion, and to reduce losses in soil organic matter. There is concern that the rapid shift to zero-till will result in an increase in the severity of leaf spot diseases such as ascochyta blight. Identifying potential problems associated with this change before they can become major problems will minimize the difficulties that growers will encounter during this transition. Recent studies indicate that the impact of changes in tillage management on disease levels in the Northern Great Plains region is often smaller than had originally anticipated based on experience in other agro-ecological regions (Bailey et al. 2000a, b, Krupinsky et al. 2000, Bailey and Gossen unpublished).

Survival of other *Ascochyta* spp. declines rapidly when material is buried in soil (Sheridan 1973, Wallen and Jeun 1968), indicating that survival may be influenced by tillage, because zero-tillage leaves more crop residue at the soil surface. This same pattern of survival was noted in a small study of *A. lentis* conducted in the Pacific northwest of the USA (Kaiser and Hannan 1986); pathogen survival declined quickly when buried, but the pathogen survived for at least 3 years at the soil surface. In contrast, microsclerotia of anthracnose [*Colletotrichum truncatum*] survive longer when buried than at the soil surface (Buchwaldt et al. 1996).

Ascochyta blight is currently the most widespread and economically important disease of lentil in the region, although the importance of anthracnose is increasing. Epidemics of blight result in significant yield and quality losses (Gossen and Morrall 1983). Foliar fungicides are registered for control of ascochyta blight, but their use requires careful management in order to be cost-effective (Buchwaldt and Gossen 2000). Blight resistance has been identified, but resistant cultivars are just beginning to be readily available to farmers. The impact of tillage and crop rotation on survival of *A. lentis* has not been examined critically, but a small survey indicated that severity of ascochyta blight was low when there was at least three crops between successive lentil crops (Gossen 1985).

Objective 1. Burial study

Methods - Lentil residue that was heavily infected with *A. lentis* was collected from a field near Laird SK in the fall of 1994. Uniform samples of stems (40 stem pieces, 6cm-long) or foliage (40 leaflets/pod pieces) were sealed in plastic mesh bags and buried at 0, 5 or 10 cm depth in 15cm-dia. plastic plant pots in a heavy clay soil. The pots were then set into the ground in the Biology Garden, University of at Saskatoon, Saskatoon, SK (which was also the source of the soil used in the trial). The trial was sampled in 26 October 1994, 26 April, 28 June, 30 August 1995, 07 May and 26 September 1996, 26 May and 19 August 1997 and the final samples were taken in 12 May 1998. At each sampling date, six bags from each plant part x depth combination were collected and the viability of the pathogen was assessed using an isolation technique and a bioassay. Each sample was air-dried for several days on a laboratory bench, and one-half of each sample (by weight) was used for isolation and the other half was used in the bioassay.

In the isolation assessment, the plant material was washed in running water for 30 min, then plated on a standard fungal growth medium (commercial Potato Dextrose Agar = PDA) and incubated at room temperature and light. After 5-10 days, the number of pycnidia per piece was counted using a dissecting microscope. In the bioassay, each sample was blended in 20 mL of sterile water in a Polytron blender, strained through a double layer of cheesecloth, and then sprayed to run-off onto 10-day-old plants of lentil cv. Eston (5 seedlings in a single pot). Twelve control pots (sprayed with sterile water) were included in each assessment. Each pot was covered with a clear plastic chamber (the base of a 2L soft-drink bottle) to maintain high relative humidity, and placed in a growth cabinet at 16°C and 16 hr photoperiod (200 μEinsteins m^{-2} sec^{-1}) for 3 days, then at 18°C and ambient humidity for 7 days (Pedersen and Morrall 1994). The number of ascochyta lesions on the leaves and stems of the plants in each pot were counted. Identification of the pathogen was confirmed by isolation onto PDA whenever symptoms were not clearly characteristic of ascochyta blight.

Results and Discussion - In 1996, we noted that the leaf and pod material buried at 5 and 10 cm was already disintegrating, and it was almost completely broken down by the spring of 1997. By fall 1997 and spring of 1998, only traces of buried residue remained, whereas residue at the soil surface was still partially intact. The buried stem samples showed some signs of breakdown by 1997, but stems at the soil surface were largely intact. In May 1998, buried stems showed signs of decomposition, but stems at the soil surface were largely intact. This pattern of breakdown is similar to that observed in a previous study on lentil residue (Buchwaldt et al. 1996).

In the spring of 1995, there was a very substantial increase in the abundance of pycnidia on plant parts over that observed the previous fall (Fig. 1, Table 1). If we had done assessments using only one assay, we might have concluded that this increase was an artifact or aberration. However, both assays showed the same pattern (Fig. 2), so we conclude that the pathogen population increased on the residue in the early spring, probably via mycelial growth within colonized pieces of residue. Pathogen populations decreased over the summer to levels similar to those observed in the fall of 1994. A similar pattern was observed in 1996, and to a lesser extent in 1997, with pathogen populations gradually decreasing over time. We were amazed at how much inoculum was still being produced from the tiny remnants of plant residue that remained in

1997. However, by May 1998, there was little or no *A. lentis* present in the leaf/pod residue (Fig. 1). In contrast, the number of pycnidia on stems increased sharply in May 1998. This increase may have been due to colonisation of the material by other pycnidial fungi, or to spread of *A. lentis* within the stems.

In the bioassay, the incidence of infection showed the same seasonal pattern as was observed in the isolation technique--higher in spring and lower in fall (Fig. 2). A similar pattern has been reported for *Colletotrichum truncatum* on lentil (Buchwaldt et al. 1996). In the fall of 1996, the pathogen was not detected in any sample, but levels rebounded in 1997. We were concerned that this fluctuation might have been due to variable humidity in the small moist chambers that were used for incubation. Variation in RH could affect the duration of leaf wetness and cause differences in infection success. Therefore, in 1998, we used a large humidity chamber that we were certain maintained a constant, high humidity. Levels of infection in 1998 were higher than they had been since early in the study. This suggests that the change in incubation conditions permitted infection by a higher proportion of the inoculum in the residue than was possible in the small humidity chambers. Unfortunately, due to an oversight, we did not plate out any lesions to confirm the identity of the pathogen, so it is possible (but unlikely) that other pathogens were present in this material.

Table 1. Significance (in ANOVA) of depth of burial on survival of *Ascochyta lentis*, assessed as the of number of pycnidia per sample in the plating study.

Date	Plating trial (# pycnidia)	
	Leaves	Stems
1995		
- April	NS	NS
- June	NS	NS
- August	NS	NS
1996		
- April	NS	NS
- September	**	**
1997		
- May	NS	NS
- September	**	**
1998		
- May	NS	**

NS - not significant; ** significant at $P \leq 0.01$.

Fig. 1. Inoculum production of *Ascochyta lentis* (# pycnidia) on infected lentil residue buried at 0, 5 or 10 cm depth at Saskatoon, SK, 1994-1998 (n = 6).

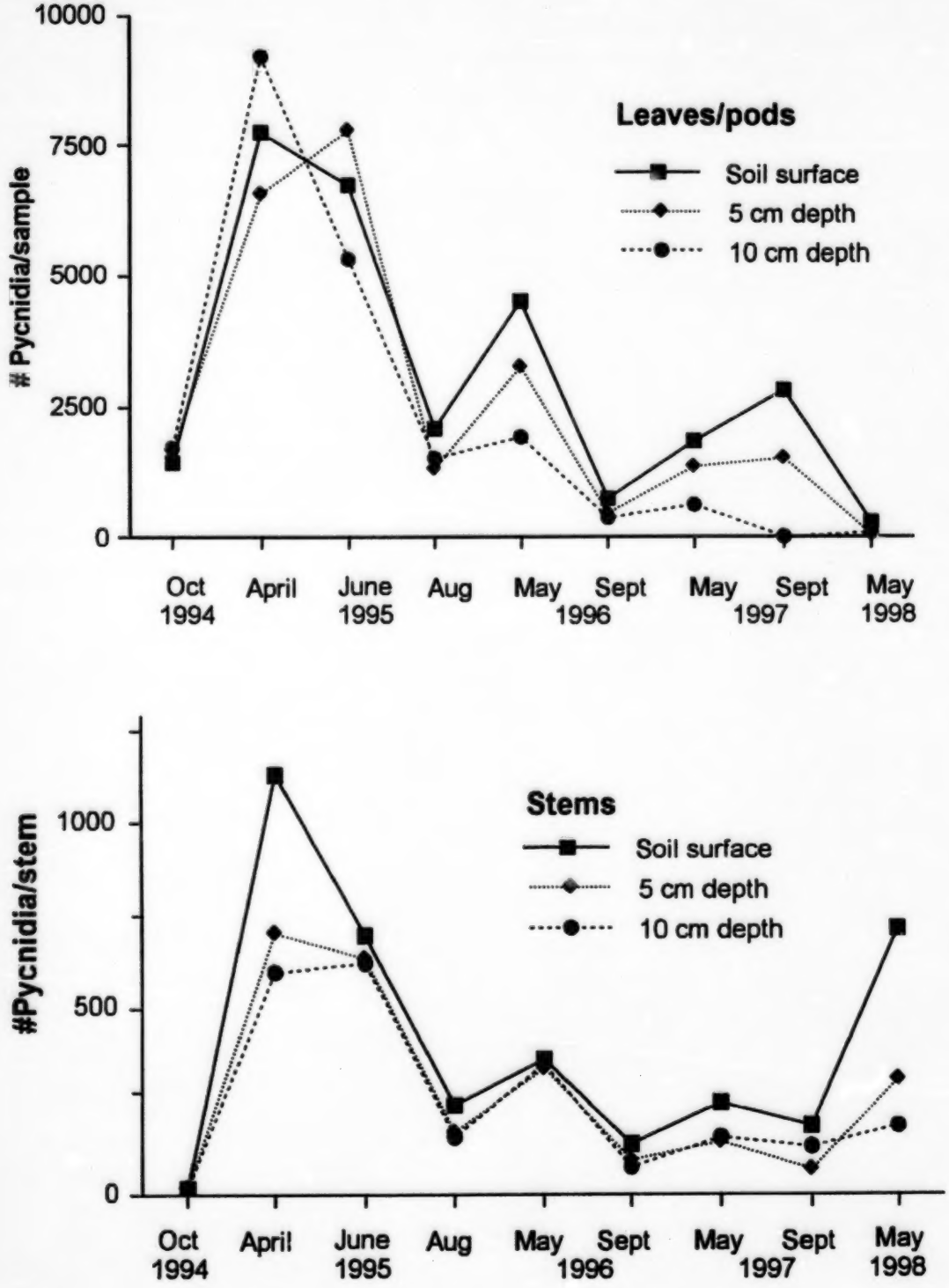
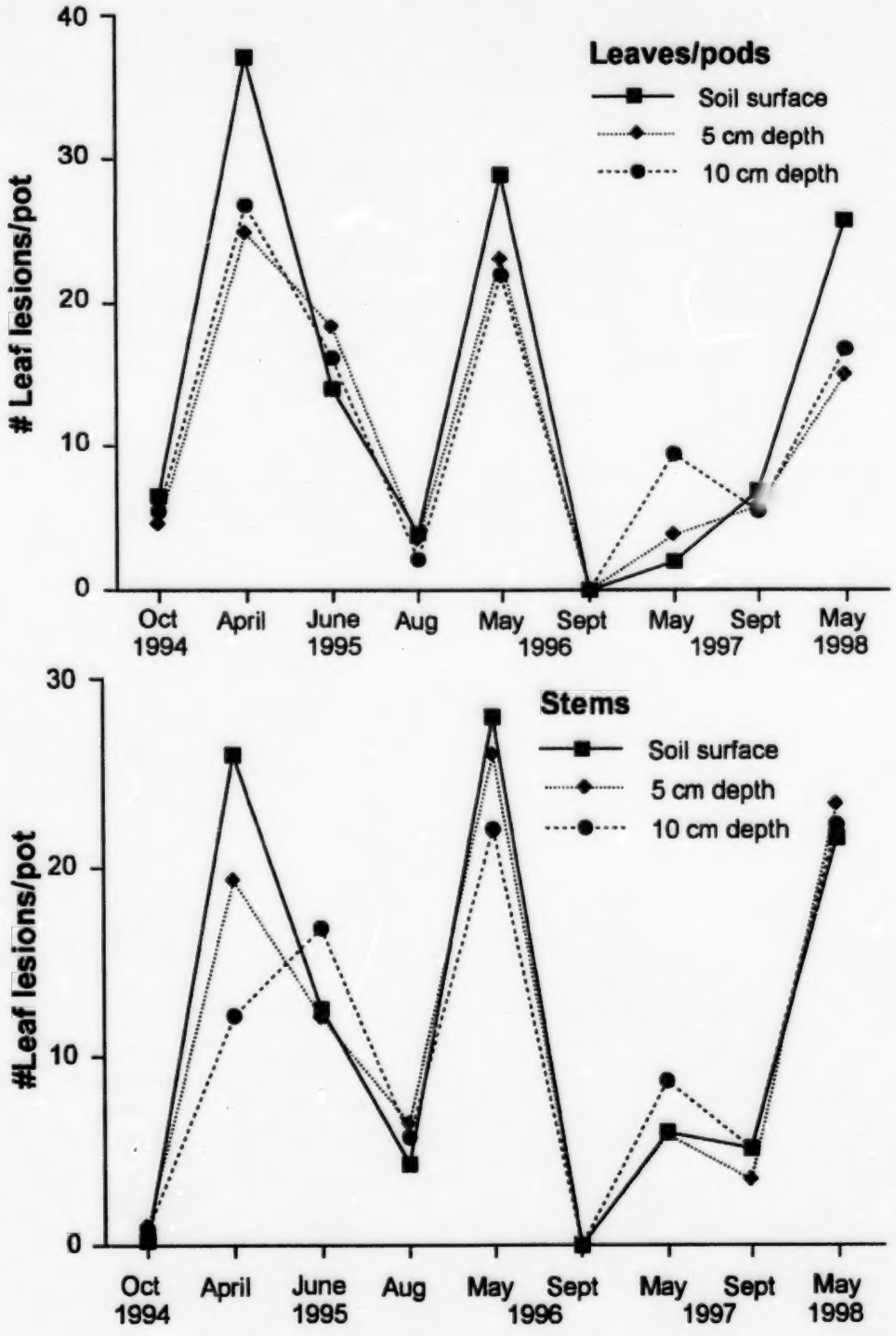


Fig. 2. Bioassay (mean infections per pot of lentil seedlings) of *Ascochyta lentis* on infected lentil residue buried at 0, 5 or 10 cm depth at Saskatoon, SK 1994-98 (n = 6).



Objective 2. Crop Rotation

Method - The objective of this trial was to assess the impact of different crops in the rotation on levels of ascochyta blight in subsequent lentil crops. A field trial was established at Saskatoon in 1995. Lentil cv. Eston (susceptible to ascochyta blight) was solid-seeded and the stand was inoculated with infected lentil residue. The intent was to produce a uniformly infected area for the experiment. The test was laid out in a 4-rep split block design, with rotation sequence as the main plots and crop species in 1996 (barley, pea, canola) as subplots. There were two rotation sequences. Both sequences started out with lentil in 1995, followed by the crop species treatment in 1996. Rotation 1 was seeded to lentil in 1997 and barley in 1998, while Rotation 2 was barley in 1997 and lentil in 1998. In 1999, we decided to extend the trial for another year, so the whole area was seeded to lentil. In addition, a positive control treatment (continuous lentil for the duration of the trial) was seeded at the south end of the plot area. A split-block design was used to minimize movement of inoculum between blocks over years. Each subplot was 5.3x5m, surrounded by a mowed strip of Dahurian wildrye grass (2m wide) to minimize movement of inoculum among plots. Foliar disease ratings were made in July after the canopy had closed, except in 1999, when ratings were made in early and late August. Foliar ratings were made on at least three locations within the plot using a 0-11 scale, and then converted to % leaf area affected (Horsfall and Barrett 1945). Also, root rot severity at harvest in 1999 was rated on 25 plants per plot using a 0-4 scale and then converted to % severity (Hwang et al. 1994). Pathogen identity was confirmed by isolation onto PDA when required.

Results and Discussion - Conditions were dry in 1995 and infection levels were low. The crop species treatments were seeded in 1996, so the only lentil treatment in the trial in 1996 was the positive control block, where lentil was seeded every year. Ascochyta blight developed rapidly and uniformly, indicating that there was sufficient inoculum for the purpose of the trial. In 1997, the weather was generally warm and dry during the growing season at Saskatoon, and as a result, levels of ascochyta blight were quite low. The plots were rated on July 30. Blight severity was higher in the continuous lentil treatment than in rotations where lentil crops were separated by a single year of either pea, canola or barley. This difference in severity was reflected in reduced seed yield and increased incidence of *A. lentis* infection in seed (Table 2). Yield in the continuous lentil treatment was 36% lower than in the other crop rotations.

In 1998, weather conditions were extremely hot and dry throughout the growing season. As a result, establishment was poor, the stands were thin and patchy, and blight severity was low in the continuous lentil treatment (Table 2), which should have had abundant carry-over of inoculum from 1997. The plots were rated on 20 July. Blight levels were higher in the continuous lentil treatment (7% leaf area infected) than in other rotations (3%), but the other crops in the rotation had no effect on blight severity. Seed yield and infection levels were highly variable due to the patchiness of the stands, and are not presented.

In 1999, the first foliar rating (early August) showed very little difference among treatments (Table 3). This supports the results from 1998 and from the burial study, which indicated that inoculum of ascochyta blight at the soil surface can survive for at least two years without substantial reduction in its potential to initiate disease. The ratings in late August were

Table 2. Impact of crop rotation on severity (%) of ascochyta blight and seed yield on lentil in Saskatoon, SK in 1997-98.

Rotation sequence℘	Blight severity (%) July	Yield (kg/ha)	Seed infection (%)
		---1997---	
1 L/L/**L**	15.0 a	685 b	14 a
2 L/C/**L**	7.5 b	1076 a	3 b
3 L/P/**L**	7.5 b	1100 a	3 b
4 L/B/**L**	5.2 b	1020 a	4 b
5 L/C/**B**	NA	NA	NA
6 L/P/**B**	NA	NA	NA
7 L/B/**B**	NA	NA	NA
		---1998---	
1 L/L/L/**L**	7.0 a	nd	nd
2 L/C/L/**B**	NA	NA	NA
3 L/P/L/**B**	NA	NA	NA
4 L/B/L/**B**	NA	NA	NA
5 L/C/B/**L**	2.3 b	nd	nd
6 L/P/B/**L**	3.2 b	nd	nd
7 L/B/B/**L**	2.9 b	nd	nd

℘ where B = barley, C = canola, L = lentil, and P = pea
† Means in a column followed by the same letter did not differ based on DMRT at $P \leq 0.05$.
NA = not applicable, nd = not done.

Table 3. Impact of crop rotation on seed yield and severity of ascochyta blight and other diseases of lentil at Saskatoon, SK in 1999.

Rotation sequence℘	Blight severity (%) 06 Aug.	23 Aug.ϕ	Yield (kg/ha)	Root rot severity (%)	Seed infection with ascochyta (%)
1 L/L/L/L/**L**	8 a	93 a	773 a	18 a	38 a
2 L/C/L/B/**L**	7 ab	89 ab	882 a	16 a	33 ab
3 L/P/L/B/**L**	5 bc	82 b	642 a	20 a	32 ab
4 L/B/L/B/**L**	5 bc	45 c	659 a	17 a	34 ab
5 L/C/B/L/**L**	4 c	26 c	877 a	13 a	37 a
6 L/P/B/L/**L**	3 c	17 cd	1056 a	14 a	33 ab
7 L/B/B/L/**L**	4 c	7 d	714 a	15 a	20 b

℘ B = barley, C = canola, L = lentil, and P = pea
† Means in a column followed by the same letter did not differ based on DMRT at $P \leq 0.05$.
ϕ Anthracnose and ascochyta blight were present and symptoms could not be distinguished.

confounded by the movement of anthracnose into the test from adjacent areas. There were no differences in seed yield among treatments, and no clear pattern of difference among treatments for seed infection. However, the high levels of ascochyta in seed indicates that ascochyta blight was a major component of the pathogen complex late in the season. The high levels of disease in late August and in the seed also illustrates how quickly epidemics can develop when conditions are favourable for disease, even when levels of initial inoculum are low.

There were no differences in root rot severity between the continuous lentil treatment and other rotations with as much as three years between lentil crops. This result was quite unexpected, but supports other recent work which suggests that the *Fusarium* spp. that cause most of this injury have a broad host range that includes cereals, canola and many of the other major crops in the prairie region. (Bailey et al. 2000a, Hwang et al. 2000, Chongo et al. 1999).

Objective 3. Tillage

Method - A trial to examine the impact of tillage on survival of *A. lentis* was established at Indian Head in 1995. As in the crop rotation trial, lentil cv. Eston was solid-seeded (zero-till) and then inoculated with infected lentil residue. Conditions were dry in 1995 and infection levels were low. Tillage treatments were applied from 1996-1999. Prior to inoculation, ascochyta blight was not present in the plot area (Bailey et at. 2000a).

The test was laid out in a 4-replicate split block design, with main plots as years between lentil crops (0,1, 2 yr) and subplots as tillage treatment (zero-till vs. conventional tillage). A split-block design was used to minimize movement of inoculum between blocks over years. Each subplot was 12x12m, surrounded by a 6m-wide strip of wheat to minimize inoculum movement between plots. Disease assessments were made as described for the rotation trial. Yields were taken each year.

Results and Discussion - In 1996, the only lentil treatment in the trial was the continuous lentil treatment; the rest of the trial was seeded to wheat. Ascochyta blight occurred uniformly throughout the plot area, but severity was low and there was no difference between the tillage treatments (Table 4). Disease severity in commercial fields in the area was also very low. We conclude that the low levels in the test were associated with low rainfall (50% of normal in July), rather than an indication of insufficient inoculum for infection.

In 1997, the plots were assessed for blight severity on 07 and 23 July and 06 August. Again, severity was low due to extremely dry weather conditions. Blight severity was higher in the continuous lentil plots than in lentil after wheat (Table 4). Tillage did not affect disease severity and there was no interaction between crop rotation and tillage. There were no differences in seed infection level associated with treatment.

In 1998, the plots were rated on 07 and 21 July, and 06 August. Blight severity was moderate to high throughout the season (Table 4). Disease levels early in the season were much higher in the continuous lentil plots than in lentil following wheat. At that time, there was an interaction between crop rotation and tillage treatment; disease severity in the continuous lentil treatment

Table 4. Impact of tillage and cropping rotation on ascochyta blight severity and seed infection incidence of lentil in a field study at Indian Head, SK in 1996-1999.

Treatment[ρ]	Blight severity (% leaf area affected) Early July	Late July	Early Aug.	Seed yield (t ha^{-1})	Seed with *A. lentis* (%)
		---1996---			
Rotation					
L/L	nd	3	nd	1.19	nd
Tillage					
Conventional	nd	3 A[†]	nd	1.14 a	nd
Zero-till	nd	3 A	nd	1.24 a	nd
		---1997---			
Rotation					
L/L/L	4 b	18 b	11 a	0.96 a	8 a
L/W/L	1 a	8 a	7 a	1.07 a	6 a
Tillage					
Conventional	2 A	13 A	8 A	1.03 A	6 A
Zero-till	3 A	12 A	10 A	1.00 A	8 A
		---1998---			
L/L/L/L					
Conventional	39b	50b	47b	0.97 a	nd
Zero-till	69c	38a	44b	0.77 a	nd
L/W/W/L					
Conventional	15a	33a	42b	0.67 a	nd
Zero-till	7a	28a	31a	0.76 a	nd
		---1999---			
Rotation					
L/L/L/L/L	nd	nd	nd	0.74 a	nd
L/W/L/W/L	nd	nd	nd	1.10 a	nd
L/W/W/W/L	nd	nd	nd	0.97 a	nd
Tillage					
Conventional	nd	nd	nd	1.09 A	nd
Zero-till	nd	nd	nd	0.73 B	nd

ρ L = lentil, W = wheat

† Means within a column, followed by the same letter, are not significantly different at $P \leq 0.05$ based on Duncan Multiple Range Test.

nd = not done.

was strongly influenced by tillage management (higher under zero-tillage than conventional till), but tillage did not affect severity where there was two years of wheat between lentil crops (Table 4). The impact of tillage and rotation on disease levels declined as the season progressed, probably due to spread of the pathogen out of heavily infected plots. There were no differences in seed yield among the treatments, but there was a tendency for yield to be higher under conventional tillage in the continuous lentil treatment than under zero-till

In 1999, no disease ratings were taken. Rotation had little or no impact on seed yield, but yield was consistently higher in the conventional tillage treatments.

We conclude that blight severity was higher under zero-tillage than under conventional tillage in the continuous lentil treatment, but only when conditions were conducive to blight development. Tillage did not affect disease severity when there was two intervening crops between successive lentil crops.

General Discussion

Each of the experiments in this study was conducted over several years, but at only one site. Multi-year trials of this nature are time-consuming and expensive, and the field trials were particularly difficult to manage because of increasing weed pressure in some of the treatments. While acknowledging that the lack of repetition is a drawback, we feel that relevant and useful conclusions can be drawn from these studies.

In the burial study, there were many more infections in the bioassay from material collected in early summer than in the late fall. A similar pattern of seasonal variation in inoculum production was reported in *Colletotrichum truncatum* (Buchwaldt et al. 1996). This same pattern was also reflected in the plating trial, which indicates that it may be associated with mycelial growth, as well as spore production. We also confirmed the results of a previous study conducted in western Canada, which showed that decomposition of lentil residue occurs more quickly when buried than at the soil surface (Buchwaldt et al. 1996). Despite the substantial differences in rates of decomposition among the burial treatments, differences in survival of *A. lentis* were small and inconsistent. This observation does not support a previous report that survival declines quickly in buried material in Washington State (Kaiser et al. 1986), but this difference may be more related to more rapid decomposition of residue in that region (especially in winter) than to actual differences in pathogen survival. However, our results support their observation that the pathogen can survive on residue (especially stems) at the soil surface for more than three years.

The crop rotation study showed that the nonhost crop following lentil did not affect subsequent blight severity. Trials at other locations have shown that a few plant pathogens are sensitive to the volatile compounds from canola residue, but there were no differences in subsequent disease development when canola, barley or pea were used as the rotation crop between successive lentil crops. When lentil was grown on lentil residue, the crop was heavily infected with blight if conditions were suitable for disease development (cool, wet weather), and both seed yield and quality were reduced.

Results from the tillage study (Table 4) support the conclusions of other tillage management trials conducted across the prairie region in recent years (Bailey et al 2000a, b, c). First, when weather was not conducive for disease development, disease severity was low, irrespective of the amount of disease inoculum available. Second, tillage had little impact on severity when crop rotations were adequate (e.g. at least 2 years of nonhosts between susceptible crops). Third, disease severity was occasionally higher under zero-till when conditions were conducive for disease increase and rotations were short. The reduction in disease severity under conventional tillage in a lentil crop following immediately after lentil is probably due to the soil providing a physical barrier that prevents the release of inoculum from buried residue. The lack of impact of tillage in subsequent years may be due to mixing of soil - repeated tillage may bring buried residue back to the surface. This result supports previous indications (Gossen 1985) that a break of at least three years between lentil crops is required to reduce levels of inoculum of ascochyta blight to acceptable levels.

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Acknowledgement:

Thanks to Judy McKell of SK Agric. & Food, who managed the site at Indian Head after Dr. Derksen transferred to Brandon, and to Ken Bassendowski, Krista Anderson and Stephanie McHale for excellent technical assistance.

Personnel

Salaries funded by Agriculture Canada

B. Gossen	Project leader	0.1 PY
K. Bassendowski	Technician	0.1 PY
D. Derksen	Cooperator	0.0 PY
J. McKell	Cooperator	0.0 PY

Salaries funded by ADF

Summer student, Indian Head	0.2 PY
Summer student, Saskatoon	0.4 PY

Equipment purchases, project materials and photos - None.

Deviations from proposal - Approved during the course of the study.

Expense statement - Provided under separate cover.

Publications and presentations

Bailey, K.L., Gossen, B.D., Lafond, G.P., Derksen, D.A. and Johnston, A.M. 2000. Impact of tillage on plant diseases in Saskatchewan. SK. Agric. & Food Factsheet. Regina, SK. June 2000. 2 pp.

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